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The effects of Google Sketchup based geometry activities and projects on spatial visualization ability of student mathematics teachers

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Abstract

Spatial visualization ability which refers to the ability to manipulate, rotate, change the position in mind of an object depicted as a picture has big importance in many disciplines such as geometry education. In order to improve this ability, it was thought that Google SketchUp, a 3D dynamic sketching software that are usually used for designing 3D building models, can be applied to geometry education. Hence the purpose of this study is to determine effects of SketchUp based geometry activities and projects on spatial visualization ability of student mathematics teachers. The model of this experimental research is pretest-posttest design with control group. In instruction of experimental group, problem based activities being related to solid objects were solved and a project was designed in SketchUp environment. In order to obtain data, Santa Barbara Solid Test which is related to identify cross sections that are 2D slices of 3D objects, was used. While no significance difference was detected between pretest scores of two groups, that there was a significant difference between two groups in favor of experimental group was seen.

Keywords: *Spatial visualization ability; Google SketchUp; geometry education; student mathematics teachers; Santa Barbara Solid Test*

1. Introduction

Spatial ability, which has always been regarded important in fields such as engineering, architecture and visual arts, is employed in daily life in many activities ranging from rearranging the furniture and objects in our houses, driving safe to finding an address or doing any kind of sport (Yıldız, 2009). Research has come up with various sub-dimensions of spatial ability such as spatial visualization, spatial perception, spatial relations, spatial orientation, and mental rotation (Linn and Petersen, 1985; Clements, 1998; Contero, 2005) Among these sub-dimensions, spatial visualization was described by Mc Gee (1979) as the ability to imagine the rotation of a represented object, to visualize the configuration, to transform a represented object into other shape, and to manipulate an object in the mind" (cited in Ben Chaim et al., 1988). This ability plays a key role in teaching mathematics and geometry. Spatial thinking makes it possible for the individual to draw shapes when solving a problem in mathematical thinking, to visualize verbal problems in the mind and to categorize any given data in tables. Ensuring that shapes are kept in the mind and the relationships among them are understood more efficiently, spatial thinking also proves helpful in geometry, which presents the relationships among shapes (Turgut, 2007). NCTM (2000) reports state that the methods encouraging students to employ their spatial skills be used in teaching. Also, Idris (2005) examined the relationship between the spatial visualization ability and mathematical achievement of a total of 1200 primary school students in Malatya with various social, economic and cultural backgrounds and reported a positive correlation

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between the two variables. The same study finally concluded that spatial visualization could be improved with several teaching methods. Similarly, both Krutetskii (1979) and Bertoline (1988) argue that spatial visualization is not a talent inherited at birth but it is a skill and they both state that it can be developed by means of several activities and teaching methods (Idris, 2005).

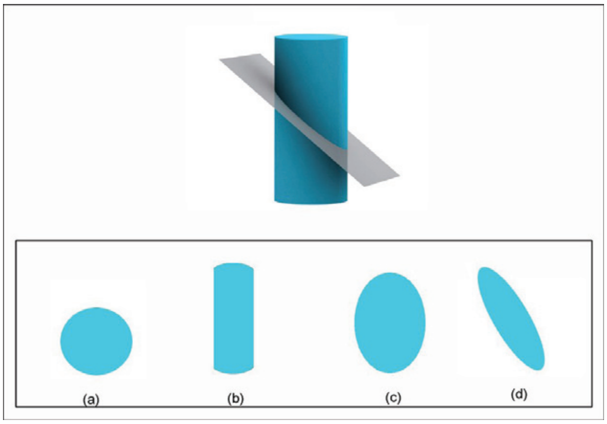
A review of the studies conducted in order to develop spatial abilities point out that those teaching methods utilizing computer software are gaining more and popularity these days. A study by Rafi (2008), for instance, examined the effect of Web-based activities and animation aided computer applications on the spatial visualization abilities of two test groups of primary school 2nd Grade students. The same study also included a control group taught through traditional teaching methods. Rafi's study finally concluded that the two test groups had higher levels of spatial ability than that of the control group. Güven and Kösa (2008), on the other hand, investigated the effect of teaching assisted with Cabri 3D, a type of 3D dynamic geometry software, on the spatial skills of teacher candidates. In that study, a total of 40 the participant teacher candidates went through several activities for 8 weeks including theory proving and rotating objects in 3D environment and surface areas by using the software. It was determined at the end of the study that the activities performed contributed significantly to the spatial ability of the teacher candidates involved in the study. In another study, Baki, Kösa and Güven (2009) compared the separate effects of making use of dynamic geometry software and concrete materials in teaching geometry on teacher candidates' spatial visualization skills. In that study, a test group was exposed to activities using dynamic geometry software and another test group was involved in activities using concrete materials while the control group was taught with traditional teaching methods. The findings from their study demonstrated that the spatial visualization skill levels of the test groups were significantly higher than that of those students in the control group. On the other hand, it turned out that the spatial visualization scores of the test group taught through dynamic geometry software applications displayed a higher increase than the scores of the other test group taught with concrete materials.

While various 3D dynamic software applications are considered to be appropriate to be used efficiently in improving spatial visualization, Google SketchUp software – a 3D drawing program used mostly in engineering – is also thought to be capable of contributing to the development of these skills. La Ferla et al. (2009) investigated the effect of using manipulations formed in Google SketchUp software while teaching three-dimensional shapes on the spatial skills of middle school students. The findings from this study, in which the participant students went through spatial relations (DAT), spatial visualization (SV) and mental rotation (MRT) tests before and after the applications, showed that the scores received by the students for spatial visualization and mental rotation increased significantly after the implementation. Finally, regarding our study, what is aimed by this study is to identify the effect of the activities and projects based on Google SketchUp while teaching solid objects on the spatial visualization skills of primary school mathematics teacher candidates.

2. Methodology

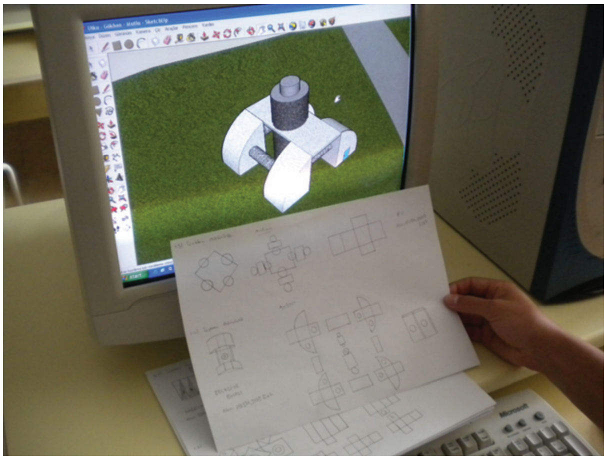
Model of this experimental research was pretest-posttest design with control group. Both two groups included twenty four each student mathematics teachers. In order to obtain data, Santa Barbara Solid Test designed by Cohen and Hagarty to measure ability of identifying cross sections that are 2D slices of 3D objects was used (Figure I). Alpha coefficient for reliability of the test which contains 30 multiple choice items was found 0.84.

Figure I. An example item from Santa Barbara Solid Test



In instruction of experimental group, problem based activities was solved with using dynamic tools and a project study was carried out on SketchUp environment while traditional geometry activities was applied to control group with using only paper and pencil. Before instructions, researchers introduced basic tools and showed usage of the software to experimental group. Afterwards, students made practice on the software to gain experience about using toolbars and building up basic objects. Next lessons students solved problems about solid objects with manipulating and analyzing 3D simulations of objects on dynamic environment. At these lessons SketchUp gave students some opportunities as sketching, rotating and cutting solid objects. On the other hand, control group solved same problems on paper without getting help from computer or any dynamic material. In project study, at first experimental group designed buildings having different and complex geometric shapes on SketchUp; then they measured their surface area and volume with using measurement tools of the software and drew their surface developments on paper. At the final lesson, students in experimental group made virtual presentations of their own products to researchers (Figure II).

Figure II. An example of student's presentations



3. Results

In this chapter, analysis results were presented by tables. In order to reveal whether there was a significant difference between pretest scores of experimental and control groups, Mann Whitney U test was applied on data. Analyze results were collated on the Table I below.

Table I. Results of Mann Whitney U test on pretest scores of experimental group and control group

	N	$\overline{X}$	$S.D.$	Z	p
Experimental Group	24	13.375	6.092	-0.052	0.959
Control Group	24	13.416	4.624		

$p > 0.05$.

According to Table I, mean level score of control group was 0.041 points higher than control group's and standard deviations of experimental and control groups were respectively 6.092 and 4.624. In addition, Z degree was calculated as -0.052 while significance degree p was found as 0.756. Because of the fact that significance degree p was found higher than 0.05, it was seen that the difference between mean level scores of two groups was not significant.

In order to determinate if the difference between pretest and posttest scores of experimental group was significant, Wilcoxon test was used and findings coming out were presented in Table II below.

Table II. Results of Wilcoxon test on pretest and posttest scores of experimental group

Experimental Group	*N*	$\overline{X}$	*S.D.*	*Z*	*p*
Pretest	24	13.375	6.092	-2.704	0,007
Posttest	24	18.833	6.162		

p < 0.05

In reference to Table II; it was clear that mean value of posttest scores was 5.468 points higher than mean value of pretest scores. Also, standard deviations of pretest and posttest scores were found as respectively 6.092 and 6.162. In addition that Z degree was detected as -2.704 and significance degree p was found as 0.007. Seeing that significant degree p was lower than 0.05, there was a significant difference between pretest and posttest scores in favor of posttest scores.

So as to see if there was a significant difference between pretest and posttest scores of control group, Wilcoxon test was applied again. Table III below shows the test results.

Table III. Results of Wilcoxon test on pretest and posttest scores of control group

Control Group	*N*	$\overline{X}$	*S.D.*	*Z*	*p*
Pretest	24	13.416	4.624	-1.570	0,116
Posttest	24	15.875	4.730		

p > 0.05

As to Table III, standard deviations of pretest and posttest scores were respectively 4.624 and 4.730. Also Z degree was calculated as -1.570 and significance degree p was detected as 0.116. Since significant degree p was higher than 0.05, the difference as 2.359 points between mean value of posttest scores and mean value of pretest scores was not significant.

In an attempt to see if there was a significant difference between posttest scores of control group and experimental group, Mann Whitney U test was performed on data. The findings are seen in the Table IV below.

Table IV. Results of Mann Whitney U test on posttest scores of experimental group and control group

	N	$\overline{X}$	*S.D.*	*Z*	*p*
Experimental Group	24	18.833	6.162		

Control Group	24	15.875	4.730	-2.244	0.025

$p < 0.05$

According to Table IV, the mean value of experimental group's posttest score was 3.042 points higher than control group's. In addition that, standard deviation of experimental group was found as 6.162 while control group's standard deviation was calculated as 4.730. Also it was clear that Z degree was -2.244 and significance degree p was 0.025, lower than 0.05. So it was determined that the difference between posttest scores was significant in favor of experimental group.

4. Discussion

According to findings, SketchUp- based activities and projects affected spatial visualization abilities. The ability of the student mathematics teachers positively was confirmed. The ability could infer the 2D slices of 3D objects. On the other hand, that conventional applications in which static tools examples of that are paper, board and two dimensional pictures were used didn't have an important effect on spatial visualization ability was seen. The result in the context of that SketchUp could be used beneficially for improving spatial visualization supported findings of Ferla (2009)'s study. Also, the result in respect of that 3D dynamic software was more effective on spatial skills than conventional instructions supported findings of Rafi (2008), Güven and Kösa (2008), Baki and others' (2009) researches. In accordance with findings, the suggestions below were offered to instructors and researchers in mathematics branch:

1. Google SketchUp can be used effectively in geometry education as an alternative for other dynamic geometry softwares to improve spatial visualization ability of students in university grade.
2. Further researches can be done in order to determine effects of Google SketchUp on geometry achievement and spatial skills of students at different grades.
3. In order to teach student mathematics teachers how to use Google SketchUp beneficially in geometry education, different activities can be made with them.
4. Future experiments can use different spatial abilty tests as a measure of performance before and after training to compare the benefits of SketchUp- based activities and projects.

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